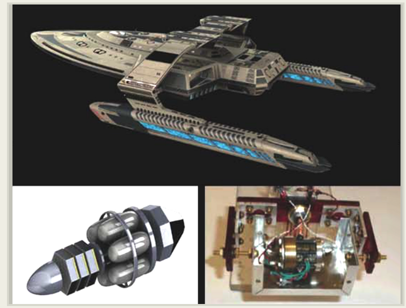
Mach Effects for In Space Propulsion: Interstellar Mission

Completed Technology Project (2017 - 2018)

Project Introduction

We propose to study the implementation of an innovative thrust producing technology for use in NASA missions involving in space main propulsion. Mach Effect Thruster (MET) propulsion is based on peer-reviewed, technically credible physics. Mach effects are transient variations in the rest masses of objects that simultaneously experience accelerations and internal energy changes. They are predicted by standard physics where Mach's principle applies - as discussed in peer-reviewed papers spanning 20 years and a recent book, Making Starships and Stargates: the Science of Interstellar Transport and Absurdly Benign Wormholes published recently by Springer-Verlag. These effects have the revolutionary capability to produce thrust without the irreversible ejection of propellant, eliminating the need to carry propellant as required with most other propulsion systems.##Our initial Phase I effort will have three tasks, two experimental and one analytical:##Improvement of the current laboratory-scale devices, in order to provide long duration thrust at levels required for practical propulsion applications.#Design and development of a power supply and electrical systems to provide feedback and control of the input AC voltage, and resonant frequency, that determine the efficiency of the MET.#Improve theoretical thrust predictions and build a reliable model of the device to assist in perfecting the design. Predict maximum thrust achievable by one device and how large an array of thrusters would be required to send a probe, of size 1.5m diameter by 3m, of total mass 1245 Kg including a modest 400 Kg of payload, a distance of 8 light years (ly) away.#Ultimately, once proven in flight and after more development, these thrusters could be used for primary mission propulsion, opening up the solar system and making interstellar missions a reality. The MET device is not a rocket, it does not expel fuel mass, and does not suffer from the velocity restriction of rockets. Freedom from the need to expel propellant means very high velocities might be achievable simply by providing electrical power and adequate heat rejection for the drive system. A mission to Planet 9 (or Planet x as it has been called) is possible in the near future using RTG power and thruster arrays. A future goal would be interstellar travel to the nearest exoplanet, within 5-9 ly distance. A mission of this type might take 20 or more years using the MET thruster. Although the nearest exoplanet is 14 or so ly distance, more Earth-like planets are being discovered daily.##This exciting TRL 1 technology, ready to take the next step to providing propellantless propulsion, first in incremental NASA smallsat missions, but later enabling revolutionary new deep space exploratory capabilities beyond anything achievable by conventional chemical, nuclear or electric propulsion systems. This unexplored opportunity has been uniquely developed by our co-Principal Investigators, breaking new ground in both science and engineering. Finally, it is technically credible - if bold and unconventional - and is fully consistent with modern physics, having been demonstrated over ten years of careful laboratory demonstration and investigation.



Mach Effects for In Space Propulsion: Interstellar Mission Credits: Top image- Mark Rademaker, Lower L- Nolan van Rossum, Lower R- Heidi Fearn

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NASA Innovative Advanced Concepts

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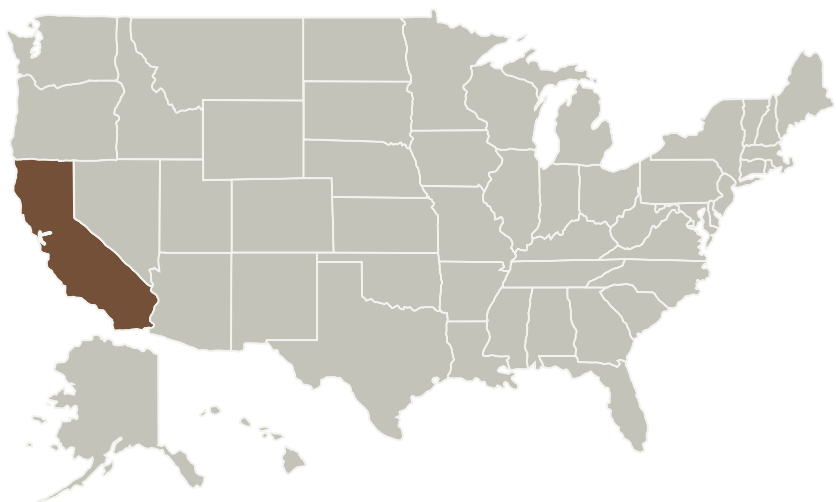
Anticipated Benefits

Mach effects have the revolutionary capability to produce thrust without the ejection of propellant, eliminating the need to carry propellant as required with most other propulsion systems. Ultimately, once proven in flight, these thrusters could be used for primary mission propulsion, opening up the solar system and making interstellar missions a reality. This aerospace concept is an exciting TRL 1 technology, ready to take the next step to providing propellantless propulsion, first in incremental NASA smallsat missions, but later enabling revolutionary new deep space exploratory capabilities beyond anything achievable by conventional chemical, nuclear or electric propulsion systems.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Space Studies Institute(SSI)	Lead Organization	Industry	North Hollywood, California

Primary U.S. Work Locations
California

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Space Studies Institute (SSI)

Responsible Program:

NASA Innovative Advanced Concepts

Project Management

Program Director:

Jason E Derleth

Program Manager:

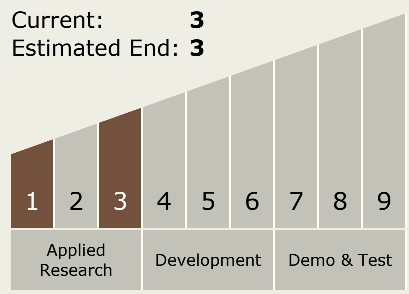
Eric A Eberly

Principal Investigator:

Heidi Fearn

Technology Maturity (TRL)

Start: **1**
Current: **3**
Estimated End: **3**



Project Transitions

April 2017: Project Start

January 2018: Closed out

Closeout Summary: Our mission is to deliver a probe with 400Kg of payload to Proxima b and send data back to Earth within a 25 year time frame. The probe d esign is set 20-25 years into the future with Mach Effect Gravity Assist (MEGA) d rives and fission (fusion) reactors we do not presently possess (in 2017-8) but w hich could conceivably be available in the near future (20-25 years time frame) and be tested and in common use within 25 years. The great challenge is to trav erse 4.2 light years, of a hazardous space environment, at sub light speeds, rea ching a maximum speed of approximately 0.4c at the half waypoint. Fortunatel y, the MEGA drive does not suffer from the restrictions of the rocket equation an d the only speed limit we see at this time is the velocity of light in a vacuum, c. The MEGA drive does not eject propellant, it only requires electricity to function and therefore no massive propellant tanks are required for the journey. We hav e the potential for all-axis attitude control and the ability to brake into the target system with the opportunity for multiple year exploration not afforded to a fly-b y mission. The electricity would be supplied by a fission (or fusion) reactor of ap proximately 5 MW thermal and 1.5 MW-electric power. It has been suggested th at these types of reactors will be available in 20-25 years time. The plan is to ac celerate for 10 years then decelerate for a comparable time into the Proxima sys tem. The incoming probe would decelerate sufficiently at a distance 50 - 100 Ast ronomical units from Proxima, and use an optical long range reconnaissance ima ger similar to the Lorri telescope on the New Horizons spacecraft (Pluto missio n). This reconnaissance phase would be necessary to both validate the orbital ep hemeris, search for other planets in the Proxima system, and to search for rings and other possible hazards to the spacecraft. Then after the reconnaissance pha se, the spacecraft would proceed to go into orbit around Proxima b and take dat a. Even with a laser communications system and a 1 meter optical telescopes fo r communications, data return would take several years at a rate of 3 Gigabytes / year (1.5 kbps with a 50% duty cycle) In order to accelerate to the half way p oint in 10 years we require a constant acceleration of 0.4 m/s2. Figure 1.2 show s an artist's impression of the probe design, which is driven by the requirements of thermal control (requiring an extensive radiator array) and shielding from bot h the reactor and the Interstellar Medium (ISM), which acts as a directed radiati on beam at relativistic velocities. The current devices are producing a small thru st of a few micronewtons. This is not sufficient for interstellar travel application s. However, the physics seems credible and worth pursuit. We recommend furth er testing. The benefits outweigh the costs of a replication at a tier 1 university and testing new materials and arrays of devices. The main emphasis on future w ork should be to increase the thrust of each device.

Closeout Link: https://www.nasa.gov/directorates/spacetech/niac/2017_Phase_I_Phase_II/Mach_Effects_for_In_Space_Propulsion_Interstellar_Mission

Technology Areas

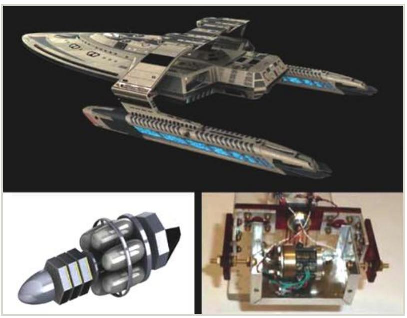
Primary:

- TX01 Propulsion Systems
  - └ TX01.4 Advanced Propulsion
    - └ TX01.4.4 Other Advanced Propulsion Approaches

Target Destination

Outside the Solar System

Images



Project Image
Mach Effects for In Space Propulsion: Interstellar Mission
Credits: Top image- Mark Rademaker, Lower L- Nolan van Rossum, Lower R- Heidi Fearn
(https://techport.nasa.gov/image/102144)

Links

NASA.gov Feature Article
(https://www.nasa.gov/directorates/spacetech/niac/2017_Phase_I_Phase_II/Mach_Effects_for_In_Space_Propulsion_Interstellar_Mission)

Project Website:

https://www.nasa.gov/directorates/spacetech/niac/index.html#.VQb6I0jJzyE